State of California
AIR RESOURCES BOARD

Quarterly Report to the California Legislature on the Air Resources Board's Fine Particulate Matter Program

Second Quarter 2000

California Environmental Protection Agency

Air Resources Board

Table of Contents

Executive Summary

This is the fourth in a series of quarterly reports to the Legislature on the Air Resources Board's (ARB) fine particulate (PM2.5) program required in fiscal year 1999-2000 budget language. This report provides background on ARB's particulate programs and covers ARB's recent accomplishments and planned activities in program areas including health and exposure research, air quality monitoring, emission inventory development, air quality modeling, planning, and control strategy development. This report includes activities funded through specific legislative appropriations, as well as programs funded through ARB's budget.

In this report, we provide a retrospective look at the last quarter (April through June) and a look forward at the upcoming quarter (July through September). Key activities from the second quarter include:

- Monitoring at the majority of sites in California's federally-mandated PM2.5 mass monitoring network began in early 1999, and we now have sufficient preliminary data to begin making comparisons among the sites. Peak 24-hour PM2.5 mass concentrations measured throughout California in 1999 reflect a wide range of values – from 20 micrograms per cubic meter ($\mu g/m^3$) in San Luis Obispo to 135 $\mu g/m^3$ in Bakersfield, compared to the federal standard of 65 $\mu g/m^3$. Annual average concentrations range from 7 $\mu g/m^3$ in Modoc County to 31 $\mu g/m^3$ in Bakersfield, compared to the federal standard of 15 $\mu g/m^3$. The highest 24-hour and annual PM2.5 concentrations are generally found in the South Coast and San Joaquin Valley, but other regions also measured levels above the standards. The highest PM2.5 concentrations typically occurred in January, November, and December, while the lowest occurred between March and August.

- We have completed an initial statewide emissions inventory for ammonia, an important precursor of particle pollution. The inventory is being used to help prioritize further efforts to more completely and accurately estimate ammonia emissions. Based on this in-house draft inventory, the major sources of ammonia on a statewide basis are livestock, natural soils and vegetation, and fertilizer application. Although urban sources of ammonia appear to be minor on a statewide basis, they may be significant at a regional or local scale. Some research is now underway to better understand ammonia emissions from the sources identified as being most significant, but additional research may be needed for major ammonia sources in those regions with high particle levels.

- In March, the Board adopted revisions to California's smoke management regulations (particulate matter is a significant component of smoke). These changes are meant to reduce the public's exposure to smoke from crop and forestry burning. The regulations will help ensure that smoke plumes don't impact populated areas. The changes will require consideration of the cumulative impacts of all fires within an airshed; increased coordination between air quality, fire agencies, land managers, farmers and ranchers; and ensure that prescribed burners evaluate and use techniques to minimize smoke.

Introduction

Particulate matter pollution is one of the most formidable air quality and public health issues facing California. Exposure to particle pollution is linked to increased frequency and severity of asthma attacks and bronchitis, and even premature death in people with existing cardiac or respiratory disease. Those most sensitive to particle pollution include people with existing respiratory and cardiac problems, children, and the elderly. Prolonged and repeated exposure can also have adverse impacts. In addition, particulate exhaust from diesel engines has been identified as a toxic air contaminant. All inhalable particles are harmful – both "coarse" particles over 2.5 microns to 10 microns in diameter and "fine" particles, those 2.5 microns or smaller.

Virtually all of California violates the state air quality standards for inhalable particulate matter less than 10 microns (PM10), which includes the subset of fine particles. Several areas, both urban and rural, also violate the federal PM10 air quality standards. In 1997, U.S. EPA promulgated new federal air quality standards for fine particulate matter 2.5 microns or less in diameter (PM2.5) to complement the existing PM10 standards. The PM2.5 standards have focused attention on understanding the nature of particle pollution and finding ways to reduce it.

Under the federal Clean Air Act, states must develop plans, known as State Implementation Plans (SIPs), describing how and when they will attain national ambient air quality standards. With ARB's technical support, the districts prepared the required PM10 SIPs. We expect PM2.5 SIPs to be due in the 2006 to 2007 timeframe. While state law does not require local districts to prepare plans for attaining the state PM10 standards, our statewide program to reduce ozone also reduces particulate levels.

The PM2.5 standards have been challenged in court by the American Trucking Association and a number of other business and industry groups. Last year, a three judge panel of the U.S. Court of Appeals for the District of Columbia returned the standards to U.S. EPA to provide a better rationale for how it selected the particular levels of the standards. In May, the Supreme Court granted a request filed by U.S. EPA and the Department of Justice to review the case. The Supreme Court has also granted a separate request from the plaintiffs to review the Court of Appeal's ruling in U.S. EPA's favor that air quality standards must be based only on health effects, not on other factors such as the economic costs of meeting the standards. The two cases will be consolidated, with arguments to be heard by the Supreme Court this fall and the Court's final ruling expected sometime in 2001.

Since the inception of the Clean Air Act, U.S. EPA has used the guiding principles that air quality standards are set only on the basis of the health impacts of air pollution and that economic costs are considered in the implementation phase, when formulating policies and programs to attain the standards. We believe that U.S. EPA is correctly interpreting the Clean Air Act, and we strongly support U.S. EPA's position. In California, we make the same distinction between setting and implementing the State air quality standards. We only consider the economic cost of attaining the State

standards when we craft implementation policies; the standards themselves are based only on the health effects of air pollution. We have also been challenged in court on this issue, and we have prevailed.

Although the PM2.5 standards remain in place, the U.S. Court of Appeals has prohibited U.S. EPA from implementing them. We expect that the standards will ultimately be implemented, either because U.S. EPA prevails before the Supreme Court or the agency provides the clarification requested by the Court of Appeals.

Unlike ozone, which is a single chemical compound, particulate matter is a complex mixture of many different species generated from a wide array of sources. Particulate matter can be either directly emitted into the air in forms such as dust and soot, or it can be formed in the atmosphere (like ozone) from the reaction of gaseous precursors such as nitrogen oxides (NOx), volatile organic compounds (VOCs), sulfur oxides (SOx), and ammonia. NOx and VOCs are also precursors of ozone pollution. Directly emitted particles are called "primary particles," while those formed in the atmosphere are referred to as "secondary particles." During some episodes of elevated particle levels in California, ammonium nitrate – formed secondarily from NOx and ammonia emissions – can account for over half of the PM2.5 mass. Understanding how ammonium nitrate is formed and how to effectively reduce it through controls on NOx and/or ammonia sources is a critical part of California's PM2.5 program.

Sources of ambient particulate matter include: combustion sources such as trucks and passenger cars, off-road equipment, industrial processes, residential wood burning, forest/agricultural burning; fugitive dust from roads, construction, mining, and agricultural activities; and ammonia sources such as livestock operations. In general, combustion processes form fine particles, whereas particles such as dust tend to fall in the coarse range. Diesel vehicles are a significant source of particle pollution from the motor vehicle fleet. Because ozone and particulate matter pollution are caused by many of the same sources and precursors, many of the control strategies in California's Ozone SIP – particularly NOx controls – provide dual benefits for public health by reducing particulate matter as well.

In the last decade, ARB has enhanced its technical and research program for particulate matter, building the scientific foundation for the PM10 SIPs adopted in the mid-1990s. ARB is now undertaking significant additional particulate matter work, including: health and exposure research; expanded air quality monitoring; emission inventory improvement; development of improved air quality models; and comprehensive field studies. Each of these technical areas plays an important role in developing California's SIP to address the federal PM2.5 standards and strategies to meet the state standards:

- *Health and exposure research* helps us understand both the impact of exposure to air pollutants (including who is susceptible to injury and the mechanisms of injury) as well as who is exposed, for how long, when, and where.

- *Air quality monitoring* provides information on which areas violate the standards and the nature and extent of the problem.

- *Emission inventories* provide an accounting of the sources of particulate matter emissions and the quantities of emissions produced from these sources.

- *Air quality models and data analyses* link air quality monitoring and emission inventory data with information on meteorology and atmospheric chemistry to tell us the relationship between emissions and air quality. Once we know this relationship, we can determine how much we need to reduce emissions to meet the air quality standards. We also use modeling to understand how air pollution is transported between regions. In support of our modeling efforts, we undertake extensive field studies to obtain the intensive meteorological, emissions and air quality data needed to run the models.

- *Clean air plans* describe how and when we will attain air quality standards. Plans include the technical foundation of monitoring data, emission inventories, and air quality models, as well as a control strategy for reducing emissions.

- C*ontrol strategy development and implementation* is the critical step. Many ARB regulations provide multiple benefits. Because they reduce emissions of both ozone and PM2.5 precursors, these controls provide dual benefits for public health. In this step, we consider technical feasibility and cost-effectiveness as well as the socioeconomic and environmental impacts.

This report covers ARB's recent accomplishments and planned activities in each of these program areas. In addition, an appendix to the report contains brief summaries of ongoing research projects.

Our program to characterize and control PM2.5 is closely related to two other ARB programs: the particulate diesel exhaust risk management efforts and regional haze program. In 1998, ARB identified particulate emissions from diesel-fueled engines as a toxic air contaminant (TAC). We estimate the statewide average potential lifetime cancer risk from breathing particulate matter from diesel-fueled engines to be 450 chances in a million (considering indoor exposure and outdoor exposure), which represents a significant threat to public health. We are now evaluating ways to reduce the risk associated with exposure to particulate emissions from diesel engines. These risk management efforts dovetail with existing efforts to control emissions to attain the particulate matter and ozone air quality standards.

In 1999, U.S. EPA finalized its new program to reduce the regional haze that impairs visibility in many national parks and wilderness areas. Because fine particles are a main contributor to visibility impairment, our particulate matter control program will improve visibility as well. U.S. EPA intends to align the timelines for PM2.5 and regional haze planning so that the necessary technical work can be coordinated.

California Regional PM10/PM2.5 Air Quality Study

The $27 million California Regional PM10/PM2.5 Air Quality Study will provide the key technical information needed to develop PM2.5 SIPs and additional particulate reduction strategies for the San Joaquin Valley and surrounding areas. This is the largest particulate matter technical study ever undertaken. The study will enhance our fundamental understanding of mechanisms of particulate formation and transport; develop methods useful in formulating candidate control strategies for attaining PM10 and PM2.5 standards in central California; and provide means for estimating the impacts of control strategies developed for PM10/PM2.5 on visibility, air toxics, and acidic aerosols and on attainment strategies for other pollutants, notably ozone.

The start of a 14-month field program last December marks a major milestone for the study. In order to address the diversity of the particle pollution problem in central California, the field program is divided into several different elements. These include: (1) a long-term program from December 1999 through January 2001; (2) a summer field program to assess visibility in the southeast desert; (3) a fall episodic program in September and October of 2000; and (4) a winter episodic program in December and January of 2000/2001. Because different conditions and different sources lead to elevated particle levels in the fall and winter seasons, we are planning specific intensive monitoring programs targeting each season. The long-term program will characterize annual average concentrations and their causes.

The field program is being conducted over a domain extending from the Pacific Ocean on the west into the Mojave Desert on the east, and from the upper Sacramento Valley on the north to the Tehachapi Mountains in the south. The field program will provide an extensive database to support data analysis and air quality modeling for use in developing plans to attain the particulate matter standards. In addition to the monitoring program, an extensive emission inventory improvement effort is underway. The improved inventory is needed for future modeling efforts and evaluations of potential control strategies.

Second Quarter 2000 Update

- **Annual Field Program Continuing.** We are continuing routine operations of the annual field monitoring program. The monitoring network consists of about 50 air quality monitoring sites and 13 meteorological monitoring sites. During the second quarter, we constructed a second, 17-meter meteorological monitoring tower at Angiola to complement the 100-meter tower built during the first quarter. We are also continuing to coordinate with U.S. EPA on the measurements being collected at the supersite in Fresno. The supersite is one of seven locations across the country outfitted with an extensive array of monitoring equipment. Data from these sites will help us better evaluate particle measurement technologies, source contributions, control strategies, and the health impacts of particulate matter.

- **Summer Field Program.** We have installed the monitoring equipment for the summer visibility study which will evaluate the magnitude, direction, and duration of visibility reduction along transport pathways from the San Joaquin Valley and the South Coast into the southeast desert. The study will consist of measurement of PM10 and PM2.5 mass, light scattering, and light absorption at Edwards Air Force Base, supplemented with additional light scattering measurements at Cantil, Bouquet Canyon, Soledad Canyon, Barstow, Cajon Pass, and Walker Pass. Monitoring for the summer field program will commence on July 1 and run through September 15.

- **Planning for Fall and Winter Field Programs.** We have finalized our plans for the special fall and winter studies, and we have started the contracting process. Contracting will continue for the fall and winter field programs. During the third quarter, we will purchase the monitoring equipment for these programs and begin setting up monitoring sites.

- **Data Management System.** We are continuing to develop database management system that will be used to archive the comprehensive data set being collected. We have prepared protocols for submitting data and distributed them to study participants.

- **Emission Inventory Projects.** We are continuing work on several emission inventory related projects. We are developing chemical speciation profiles for key sources of organic particulate matter. These profiles will be used to correlate particulate matter samples collected in the air with contributing emission sources, which should ultimately help us effectively target our control strategy. We are also collecting improved activity data and spatial and temporal profiles of emission sources in the study area. We are also reviewing proposals submitted by contractors for the preparation of a spatially-resolved ammonia inventory for the region.

Health and Exposure Research

ARB has long recognized that particulate matter is harmful and has taken a lead in research to more clearly define how particle pollution impacts the health of Californians. Extensive research programs are underway both nationally and within California to clarify some of the uncertainties regarding who is at risk, whether a truly safe level of particulate matter can be determined, the mechanism of injury, and the role of specific components of particulate matter in producing harmful health impacts. ARB is also a leader in research on exposure to particles and their toxic components in indoor, outdoor, and in-vehicle environments. We also publish practical guidelines on how to reduce personal exposures to indoor and outdoor pollutants, including particles.

The ongoing particulate matter health and exposure studies being funded by ARB are highlighted in the appendix to this report. The following section provides updates on significant milestones from the past quarter.

Second Quarter 2000 Update

- **Vulnerable Populations Research Program.** Earlier this year, we took a major step towards implementing the Vulnerable Populations Research Program when the Board selected the University of California at Berkeley to conduct an investigation of how community air pollutants impact the nature and progression of asthma in school-aged children. This summer, we will start recruiting approximately 450 asthmatic children from the Fresno area for this study. Their respiratory health will be evaluated periodically over four years of field efforts. Intensive community, home, and school-based monitoring will be performed to produce a refined estimate of air pollution exposure for each participant. Fresno was selected as the study location because the community has a high level of childhood asthma, as well as persistent poor air quality. It is also the site of two extensive air-monitoring efforts, the California Regional PM10/PM2.5 Air Quality Study and a federal particulate matter monitoring supersite. These monitoring studies will form the backbone of air quality data that will be augmented to meet the needs of the health study. The study is expected to begin field operations this summer.

- **Indoor Air Quality Update.** In May, ARB and the Department of Health Services sponsored a two-day symposium in Sacramento entitled "Indoor Air Quality: Risk Reduction in the 21st Century" which focused on the risks posed by indoor pollution and actions needed to address this problem. We discussed sources, exposure levels, and effective risk reduction techniques for PM2.5 and other indoor pollutants. In addition, we have published a fact sheet that discusses how well air cleaners and furnace filters remove airborne particles and gases in homes, and which air cleaning methods are not effective.

- **Health and Air Quality Impacts of Smoke from Forest Fires.** We are working with the Office of Environmental Health Hazard Assessment (OEHHA) to improve both agencies' ability to assist local communities respond to wildfire-related air pollution episodes in order to minimize adverse public health impacts. Last year, smoke from forest fires affected many communities in northern California. Forest fires can result in extremely high community and worker exposures to particulate matter and other pollutants. In the most extreme case last year, a Hoopa Indian community was evacuated because of high smoke levels. In May, we participated in an OEHHA workshop on forest fire smoke exposure. Several critical needs were identified including the need to better measure and predict smoke levels in time to warn the public and the need for better information on smoke exposures and health effects. We provided input on potential ways to reduce these exposures through better pollutant monitoring methods, monitoring programs, and public information efforts.

Air Quality Monitoring

California's air quality monitoring program provides information used for determining which areas violate standards, characterizing the sources that contribute to pollution, assessing pollution transport, and supporting health studies and other research. Monitoring data also provide the ultimate check on how effective our programs are – is the air quality improving? California already has a PM10 air monitoring network with over 150 monitors statewide. To assess the nature and extent of the PM2.5 problem in California, ARB and local air districts are enhancing and expanding the PM2.5 monitoring program. This effort began in 1998 and will continue for several years until our network is fully deployed. The first step in deploying this new network was the siting of PM2.5 mass monitoring equipment. We have already placed federally-approved PM2.5 mass monitors at 81 of 83 proposed sites across California. We anticipate that mass monitoring equipment will be deployed at the remaining two sites by the end of 2000. These monitors collect particulate samples on filters which are later weighed and analyzed in a laboratory. Because of this two step process, PM2.5 air quality data collected with these monitors are not immediately available. To provide "real-time" PM2.5 air quality information, we are adding continuous PM2.5 mass monitors to our network.

The second step will be the deployment of PM2.5 speciation monitors. Speciation monitoring provides valuable information about the composition (and ultimately sources) of PM2.5 pollution. However, monitoring of the individual species that make up particulate matter is still an emerging field, with continuous speciation measurements the greatest challenge. To develop the best speciation network, California will need to take full advantage of emerging technologies – including instrumentation that is not yet commercially available. We are participating in the development of new sampling technology and critical research in this field, including special studies to evaluate newly emerging methods not currently used in routine monitoring. With previously allocated funds, we will complete the deployment of seven federally-required speciation monitors by the end of 2000. Additional speciation monitors are planned for future deployment, pending further assessment of which technologies are the most effective.

Our statewide particulate monitoring network is complemented by two "supersites" – one in Fresno and one in southern California. U.S. EPA is establishing seven supersites nationwide which include an extensive array of monitoring equipment. Data collected at these sites will help in better understanding particle measurement technologies, source contributions, control strategies, and the health impacts of suspended particles.

Second Quarter 2000 Update

- **2000 California Particulate Matter Monitoring Network Description**. We completed the federally required 2000 Particulate Matter Network Description and submitted it to the U.S. EPA in late June. The document (available on our

website at www.arb.ca.gov/aqd/pm25/pmfdsign.htm) includes a summary of particulate monitoring-related activities during the last year and a look at activities planned for the next 12 months. In producing the 2000 Particulate Matter Network Description, we coordinated closely with both the local districts and U.S. EPA. The document contains several proposals related to expansion of the PM2.5 filter-based mass monitoring network, designation of mass monitoring sites as National Air Monitoring Stations (NAMS sites), deployment of PM2.5 speciation monitors, and deployment of continuous PM2.5 mass monitors. These proposals are summarized below.

- Expansion of PM2.5 Filter-Based Mass Monitoring Network. By the end of the year, we anticipate deploying monitors at the final two sites to complete our 83 site PM2.5 mass monitoring network of federally-approved filter-based monitors. The data collected at these sites will be used to determine attainment of the national PM2.5 standards.

- Designation of PM2.5 NAMS. Federal regulations require that a number of PM2.5 mass monitoring sites be designated as National Air Monitoring Stations or NAMS trends sites. These are long-term sites that can be used to track trends that establish progress toward attainment of the national standards. We proposed designating 20 sites in California as PM2.5 NAMS sites. In choosing the sites, we selected sites that experienced high ambient concentrations during 1999 and sites located in areas with high populations. We also gave preference to those sites that have been in operation for several years (monitoring PM10) and that are likely to remain in operation for the foreseeable future. Finally, we selected sites that broaden the geographical representation of the network and that have the most frequent PM2.5 sampling schedules. Final approval of the sites we have proposed rests with U.S. EPA.

- PM2.5 Speciation Monitoring. There are two components to the PM2.5 speciation network in California. The first component, mandated by the U.S. EPA, requires filter-based PM2.5 speciation monitoring at seven California sites that will be part of a national trends network for PM2.5 speciation. These monitors will be the NAMS monitors for the speciation network. We have already deployed PM2.5 speciation monitors at three of these sites, located in Fresno, Sacramento, and San Jose. Data collected at these sites will be used to support the California Regional PM10/PM2.5 Air Quality Study and also a “mini-trend” study and instrument performance evaluation being conducted by U.S. EPA. The goal of the “mini-trend” study is to evaluate different sampling methods, and results are expected by the end of the summer. We will use information from the “mini-trend” study in selecting speciation monitors for the remaining four sites (Bakersfield, El Cajon, Riverside, and Simi Valley). We expect speciation monitors for these sites will be purchased and deployed by the end of 2000.

The second component of California's PM2.5 speciation network is the selection and deployment of samplers at selected State and Local Monitoring Stations or SLAMS. Data from these sites will provide additional information needed for developing effective air quality attainment plans. The focus of the SLAMS PM2.5 speciation network will be potential nonattainment areas that do not have data available from special studies. We propose a phased approach to the deployment of the SLAMS portion of the speciation network. The first phase will evaluate sampling technologies. While preliminary evaluations have identified promising technologies, additional study is needed before selecting monitoring technologies for the full SLAMS speciation network. Whereas U.S. EPA is specifying the monitors to use at the seven required NAMS speciation sites, we can choose the type of monitoring technology to employ for this part of the network. We will consider both filter-based and continuous speciation samplers. As part of this evaluation, we are purchasing a number of speciation samplers employing several different sampling technologies. These advanced technology samplers include seven continuous nitrate analyzers which provide measurements of the nitrate fraction of fine particulates, one continuous carbon analyzer which measures the carbon fraction of particulate matter, one field ion chromatograph which allows continuous analysis of particulate species (such as nitrate, ammonium, and sulfate), and two aethalometers for the continuous measurement of particulate carbon. Based on the length of time required for the technologies to further develop, for field testing, and for evaluating the results, it is likely that selection and deployment of samplers in the SLAMS PM2.5 speciation network will not begin until 2001.

- Continuous PM2.5 Mass Monitors. Continuous PM2.5 mass monitors provide valuable information for public reporting, temporal representation, health studies, transport study, and background monitoring. By the end of 2001, we expect a total of about 37 continuous PM2.5 mass monitors to be deployed. Of these 37 monitors, 21 are already committed to various programs and locations. We propose to locate approximately 10 of the remaining 16 monitors at sites designated as PM2.5 NAMS mass monitoring sites (see previous discussion). In addition, four monitors will be collocated for quality assurance/quality control purposes, one monitor will be sited to support an evaluation of the benefit of continuous monitoring to the Sacramento Valley smoke management program, and one monitor will be held in reserve to allow rapid replacement if a monitor breaks. Deployment of these monitors has already started.

- **PM2.5 Air Quality in 1999.** The majority of sites in California's federally-mandated PM2.5 mass monitoring network began sampling in early 1999 and now have sufficient preliminary data for making some comparisons among the

sites. A summary of the preliminary 1999 PM2.5 data is available in the 2000 California Particulate Matter Monitoring Network Description. The peak 24-hour PM2.5 mass concentrations measured throughout California during 1999 reflect a wide range of values. The peak concentrations among sites with complete data range from 20 $\mu g/m^3$ in San Luis Obispo to 135 $\mu g/m^3$ in Bakersfield, compared to the federal 24-hour standard of 65 $\mu g/m^3$. Measured annual average concentrations range from about 7 $\mu g/m^3$ at Alturus, in Modoc County, to 30 $\mu g/m^3$ at Riverside and 31 $\mu g/m^3$ at Bakersfield, compared to the federal annual standard of 15 $\mu g/m^3$.

In general, both the highest 24-hour and annual average PM2.5 concentrations are found at sites in the South Coast and San Joaquin Valley. However, PM2.5 levels near or exceeding the standards have been recorded in California's other major urban areas – Sacramento, San Diego, and the Bay Area. While these data provide a first indication of potential federal nonattainment areas, three complete years of air quality data are needed before areas can be formally designated as attainment or nonattainment for the federal PM2.5 standards. Regardless of whether these areas are ultimately designated nonattainment for the PM2.5 standards, all continue to violate the State PM10 air quality standards.

On average, the highest 24-hour concentrations in 1999 occurred in January, November, and December, while the lowest occurred between March and August. Most areas follow this seasonal pattern to some degree. The cooler winter temperatures tend to favor the formation of secondary particle like ammonium nitrate. In addition, some PM2.5 sources such as smoke from fireplaces are more prevalent during the winter months. The seasonality is most pronounced in the San Joaquin Valley, where the January-November-December concentrations were on the order of 4 to 5 times greater than those for March through August. The San Francisco Bay Area, San Diego, Sacramento Valley, North Coast, Mojave Desert, and Imperial County also showed this seasonal pattern, but to a lesser degree. Two notable exceptions to this seasonal pattern are the South Coast and Coachella Valley, where fairly high PM2.5 levels occurred throughout the year.

Emission Inventory Development

Over the last year, ARB has embarked on a program to identify and characterize the sources of emissions of PM2.5 and its precursors. This work will lead to the development of a statewide inventory of the emissions and sources of PM2.5. The inventory will include estimates of future emissions, which consider growth and the benefits of adopted air quality programs. By accurately quantifying PM2.5 emission sources, we can better target our control strategies.

ARB's existing emission inventory includes particulate emissions estimates for directly emitted PM10. Our inventory also includes estimates for gaseous precursors, such as NOx, SOx, and VOCs. We are now incorporating emission estimates for

PM2.5, as well as additional particulate precursors such as ammonia. Because PM2.5 emissions are difficult to measure and characterize, this will be a multi-year effort. By 2001, we intend to produce draft emission inventories for PM2.5 and ammonia, which can be used for identifying the most important sources of PM2.5 air pollution. These inventories are being developed in coordination with the air districts, air agencies in other states, U.S. EPA, industry, and researchers.

ARB funds a number of projects to quantify and better understand PM2.5 emissions from stationary, area, and mobile sources. These are summarized briefly in the appendix to this report.

In addition, ARB has taken over the operation of the chassis dynamometer testing facility originally managed by the Los Angeles Metropolitan Transit Authority. This facility is being used to perform both engine- and chassis-based emissions tests (including PM2.5) of heavy-duty vehicles on a regular basis. (Chassis dynamometers are treadmill-like devices that test engine-vehicle combinations. Engine dynamometers test engines that have been removed from, or are not yet installed in, vehicles.) The use of chassis dynamometers that accommodate trucks and buses will allow us to measure in-use emissions from these vehicles. Previously, we had only very limited opportunities to make these types of measurements. Data will be used to update the emission inventory.

Second Quarter 2000 Update

- **Draft Ammonia Inventory Completed.** We have completed an initial statewide emissions inventory for ammonia. The inventory includes all known source categories of ammonia and is being used to help prioritize our further ammonia emissions estimation efforts. Based on this in-house draft inventory, the major sources of ammonia on a statewide basis are livestock, natural soils and vegetation, and fertilizer application. Although urban sources of ammonia appear to be minor on a statewide basis, they may be significant at a regional or local scale. Some research is now underway to better understand ammonia emissions from the sources identified as being most significant. We are also improving the spatial resolution of this inventory to a county or possibly sub-county level to help identify the most significant source categories at the local level. Additional research may be needed for major ammonia sources in those regions with high particulate levels. Continuing to refine our ammonia emissions estimate will be a priority during the third quarter.

- **Ongoing Research Projects.** The fiscal year 1999-2000 PM2.5 inventory research projects that were described in the previous quarterly report are now in progress. These new projects include an analysis of unpaved road traffic, estimates of emissions from wood burning stoves and fireplaces, evaluation of dust transport and suspension near emission sources, and improvements in estimates of agricultural burning emissions. (These new projects as well as other ongoing emission inventory research projects are described in greater detail in

the appendix.) Coordinating these and other existing research projects to improve our PM2.5 emission estimates will continue to be a high priority during the third quarter. As results become available, we will use the information to prepare PM2.5 emission inventory estimates.

- **Coordination with Other Agencies.** During this past quarter, we participated in many outreach and coordination efforts with industry and other agencies to help support our PM2.5 emissions inventory work. In upcoming months, we will continue these partnerships at the local, state, and national level. We made presentations regarding our ammonia emission inventory development at a national U.S. EPA/U.S. Department of Agriculture (USDA) workshop on improving emission estimates from livestock, the University of California at Davis Animal Science Coordinating Conference on the effects of livestock on air quality, the Kern County Dairy Technical Advisory Committee meeting, and the California Feeder Council (beef feedlot operators) meeting. Through these meetings, we have formed good working partnerships with industry and researchers who have agreed to provide their expertise to assist with our inventory development. These partnerships also help us better coordinate our efforts with the work being performed by other states and at the national level. In addition, we also made several presentations to stakeholder groups on our new inventory research projects, smoke emissions research efforts, and emissions from commercial cooking operations.

Air Quality Modeling

ARB develops air quality models and runs these models to predict how emissions, weather, and terrain influence ambient levels of pollutants, based on monitoring data, emission inventories, and atmospheric chemistry. Air quality models are also used to determine the emission reductions needed to achieve air quality standards and to evaluate the effectiveness of control strategies. Regional models are used to assess pollution transport from one area to another. These types of transport assessments are needed to ensure that necessary actions are taken in both upwind and downwind districts to meet air quality standards.

California has developed some of the most advanced photochemical models in the nation for ozone. However, the state of modeling is not as advanced for particulate matter, in part because of a lack of the extensive air quality and meteorological data needed to run modeling simulations. We are working to advance the state of particulate matter modeling for use in developing PM2.5 attainment plans and particulate matter control strategies. Data collected during the California Regional PM10/PM2.5 Air Quality Study field program will be used to evaluate and improve the performance of our meteorological and air quality models.

For attainment planning, the PM2.5 modeling analyses must show the “carrying capacity,” or how many tons of emissions each affected area can hold before it exceeds the daily or annual PM2.5 standards. The carrying capacity for PM2.5 and precursors

determines the type and amount of emission reductions needed from new control measures. PM2.5 models will also form the basis for regional haze models to assess the impact of our control strategies on visibility in California and in downwind states.

Planning

The timeline for developing PM2.5 attainment plans (SIPs) is dictated by when nonattainment areas are designated, which in turn is dictated by when sufficient PM2.5 air quality monitoring data are available. Although California had a small pre-existing PM2.5 monitoring network, no nationwide PM2.5 monitoring network or federally approved monitor for measuring PM2.5 existed when the new federal standards were promulgated in 1997. In 1999, we began collecting PM2.5 monitoring data using the federal reference method for comparison to the standards. Three years of monitoring data are needed to designate areas as attainment or nonattainment. In addition, when U.S. EPA promulgated the PM2.5 standards, it agreed to complete its next health review of the standards prior to designating areas. That review is scheduled to be finished in 2002. Thus, we expect nonattainment areas will be designated in 2003, at the earliest. SIPs would then be due three years later – or 2006 at the earliest. In the meantime, PM10 nonattainment areas will continue implementing their PM10 SIPs. Many of the strategies in these plans reduce PM2.5 as well because PM2.5 is a part of PM10.

This schedule is still tentative – in part, due to an ongoing legal challenge to the new standards. Because the planning timelines are relatively long and deployment of the monitoring network is not being delayed, it is likely that the legal challenge will be resolved without ultimately delaying the schedule for submitting PM2.5 SIPs. Once the court case is resolved, U.S. EPA will issue guidance detailing the specific planning requirements and timelines for the PM2.5 standards.

For regional haze, U.S. EPA intends to require visibility SIPs at the same time as PM2.5 SIPs. The new regional haze regulation also provides an alternative approach for the nine states which participated in the Grand Canyon Visibility Transport Commission (including California). These states may choose to pursue an accelerated plan submittal in 2003, based on the Commission's recommendations for improving visibility at the Grand Canyon. We expect to pursue both approaches. We will coordinate with other western states as we develop a regional haze SIP in 2003 to address our contribution to visibility impairment in the Grand Canyon region. We will address visibility concerns for national parks and wilderness areas in California in coordination with our PM2.5 SIPs in the 2006 timeframe.

Second Quarter 2000 Update

- **California Joins the Western Regional Air Partnership.** In April, Governor Davis announced that California would join the Western Regional Air Partnership (WRAP). The WRAP is charged with implementing the Grand Canyon Visibility Transport Commission's recommendations for improving

visibility in 16 national parks and wilderness areas on the Colorado Plateau, as well as the federal regulations designed to improve visibility in parks nationwide. The WRAP is made up of 12 states, 12 Indian tribes, and 3 federal agencies (U.S. EPA, USDA, and U.S. Department of the Interior). Since the WRAP formed in 1997, California has been a technical resource on emissions inventory, modeling, and control strategy development. Official membership will ensure that California is a full participant in western regional air quality coordination.

Control Strategy Development and Implementation

ARB develops control strategies for stationary, area, and mobile sources to reduce emissions and achieve air quality goals. The development of control strategies is based on emission inventories and modeling data, considering the need for additional reductions to meet state and federal requirements, existing controls, and technical feasibility. Control strategies are also evaluated for cost-effectiveness, and socioeconomic and environmental impacts. Our assessment of the controls needed to attain state and federal standards will include estimating the PM2.5 benefits from current and planned control programs for PM10 and ozone.

In addition to regulations, we are pursuing emission reductions from voluntary programs, such as the Carl Moyer Program. This program provides grants for the incremental cost of cleaner trucks, buses, boats, agricultural equipment, and other diesel engines. The program is designed to reduce NOx emissions (which provide dual benefits for ozone and PM2.5); however, many of the projects also reduce direct particulate matter emissions. For example, projects that replace diesel engines with natural gas engines reduce NOx and eliminate diesel particulate emissions. The program seeks to accelerate emission reductions from diesel engines by providing grants to cover part of the cost of purchasing cleaner engines. To date, the program has been funded with one-time State appropriations of $25 million for FY 1998-99 and $23 million for FY 1999-00 ($19 million for heavy-duty engine projects and $4 million for infrastructure and advanced technology development). Local air districts administer the program and must provide a one dollar match for every two dollars of State funds. The program has been well-received with demand for project funding about three times the available funding.

Efforts to develop and implement control strategies to meet particulate matter air quality standards relate closely to our efforts to characterize and manage the risk associated with toxic particulate emissions from diesel engines. An advisory committee of representatives from industry, environmental groups, government agencies, and the public is assisting with our risk management activities.

Second Quarter 2000 Update

- **Smoke Management Regulations.** In March, the Board adopted revisions to California's smoke management regulations (particulate matter is a significant component of smoke). These changes are meant to reduce the public's

exposure to smoke from crop and forestry burning. The regulations will help ensure that smoke plumes don't impact populated areas. Most of the changes address the use of "prescribed" fire in forests or rangelands. The regulatory changes will require consideration of the cumulative impacts of all fires within an airshed; increased coordination between air quality, fire agencies, State and federal land managers, farmers and ranchers, both within and between airsheds; and ensure that prescribed burners evaluate and use techniques to minimize smoke.

- **Carl Moyer Program (Reduction of Diesel Emissions) Update.** For FY 2000-2001, the Governor is proposing a one-time appropriation of $50 million ($45 million for ARB and $5 million for CEC) for the program.

  We are currently developing technical modifications to the Carl Moyer Program Guidelines as directed under AB 1571 (1999) and recommended by the Carl Moyer Program Advisory Board. The most significant modification to the guidelines would be the addition of a 25 percent particulate matter reduction target/requirement for projects funded under the program. The proposed modifications will be presented to the public at a workshop in late Summer 2000. The technical modifications to the guidelines are scheduled for presentation to the Board for its review and approval in Fall 2000.

  By June 30, all districts participating in the program are required to provide ARB with a written report documenting the status of their programs. Each district report will include a summary of all the projects a district has funded with 1998-99 fiscal year funds, both project and program NOx reductions and associated cost-effectiveness. We will evaluate all district reports and develop a status report which we will present to the Board in Spring 2001.

- **Diesel Risk Management.** We are continuing to develop a risk management plan (also known as the "needs assessment") which will: identify the current public health impact of particulate emissions from diesel-fueled engines; assess the effectiveness of programs currently in place; and determine what technically and economically feasible strategies could be pursued to further reduce emissions. We are also developing guidelines to assist the districts in permitting new and modified stationary sources that operate diesel-fueled engines. A major priority during the third quarter will be finalizing both reports. We intend to present the reports to the Board in September.

- **Air Quality and Agriculture Forum.** On June 8, ARB and the California Department of Food and Agriculture (CDFA) held a forum in Tulare on air quality and agriculture. The forum brought together key representatives from the agricultural industry and government agencies to discuss air quality issues related to agriculture. Topics discussed included current research and voluntary measures to reduce particulate and smog forming emissions from agricultural operations.

- **Heavy-Duty Vehicle Roadside Inspection Program.** Under the Heavy-Duty Vehicle Inspection Program, inspectors conduct random roadside tests of diesel trucks to ensure that smoke emissions are within acceptable levels and that emission control devices have not been tampered with. Owners of failing vehicles are issued citations and required to make repairs. Through the end of May, we have inspected over 40,000 vehicles since the program was restarted in June 1998 (with over 7,000 inspections since our last report). The total inspections have resulted in more than 2,300 citations and 720 non-penalty "fix-it" tickets. The failure rate has decreased from 11 percent when the program was first restarted to a current 7.7 percent. More than 2,100 trucks and buses have been repaired to date. We have instituted a formal program to pursue those owners who are delinquent in clearing their citations in order to ensure that repairs are made. Industry acceptance of the program is good, as indicated by the low rate of citation appeals – two percent. The penalties that we collect though the inspection program are recycled back to the industry in the form of incentive programs that promote cleaner heavy-duty engines.

- **Periodic Self-Inspection Program.** The Periodic Smoke Inspection Program requires all California fleets with two or more trucks or buses to perform annual smoke and anti-tampering inspections and repair failing vehicles. The first annual self-inspections of heavy-duty diesel-powered vehicle fleets had to be completed by October 1, 1999. Through the end of May, we have conducted more than 1,800 fleet audits and found a compliance rate of 51 percent. Of the remaining non-complying fleets, about 90 percent have made partial compliance efforts, while 10 percent have taken no steps to comply with the program. We are working with owners of non-complying fleets to bring their fleets into compliance.

Appendix

Summary of Ongoing Particulate Matter Research Projects

Health Effects and Exposure Research Projects

- **Children's Health Study:** This major epidemiological study follows the lung development and respiratory health of approximately 5,000 school children from 12 southern California communities in 4th through 12th grades. The study will continue through 2003.

- **Cardiovascular Health Study:** This study evaluates how air pollution, including particulate matter, impacts the well-being of a group of elderly people, especially as related to their cardiac health status.

- **Health Impacts of Smoke:** This study evaluates the respiratory health impacts experienced when people breathe smoke from burning such common materials as rice straw, wood wastes, and wood used to heat homes.

- **Toxicological Studies of Particles:** Studies are underway in which rats are exposed to synthetic components of ambient particulate matter. These studies are evaluating cellular and tissue responses to these components, and how factors such as animal age and particle size affect observations. We hope this research will provide information on the physiological mechanisms that produce the adverse impacts observed in community health studies.

- **Kaiser Hospital Study:** This is a study of how air pollutants impact the rates of hospitalization in the Kaiser Hospitals located in the Central Valley. This study should help clarify the role that particulate matter plays in cardiovascular and respiratory illness in the region.

- **Vulnerable Populations Research Program:** We are currently planning several studies as part of our vulnerable populations health research initiative. The focus of this program is to determine how air pollution, including particulate matter, impacts health, and how environmental and individual health, lifestyle, and socioeconomic factors effect sensitivity to air pollution. The initial research efforts include a study of how children with asthma respond to air pollution. The study will be performed in Fresno, which has a persistent and complex particulate air pollution problem and a high rate of asthma. This study is being coordinated with major particulate air pollution monitoring efforts in the Fresno area.

- **Residential Indoor Cooking Exposures Study:** This is the most comprehensive study of cook and occupant exposures to indoor PM2.5, PM10, ultrafine particles, and gaseous co-pollutants during residential cooking. We will

use the data from this study to improve exposure estimates and to further explore the correlation between elevated personal exposure levels and cooking activities seen in previous studies. The data will also be used to provide guidance to the public on reducing their pollutant exposure.

- **Sources of Personal, Indoor, and Outdoor PM Exposures of Chronic Obstructive Pulmonary Disease Patients:** The main objective of this study is to quantify the contribution of outdoor air to indoor and personal PM2.5 exposure levels. Results of this study will enable us to better understand the link between outdoor PM2.5 and the health effects seen in sensitive individuals.

- **Exposure Model Enhancement:** This project will enhance the capabilities and accessibility of a model to estimate total exposure to particles and other air pollutants from all microenvironments – indoor and outdoor. The model is based on California data for pollutant concentrations, building ventilation, and human activity patterns. We will use the model to more accurately estimate Californians' exposures to particles, including toxic components such as diesel particles and metals. We can also use it to evaluate the effectiveness of different risk reduction strategies.

Air Quality Monitoring/Atmospheric Processes Research Projects

- **Biological Fingerprinting for Dust Sources:** Source apportionment models are used to relate monitored particulate species back to emission sources. Work is underway to explore the use of biochemical markers (such as fatty acids and microbial DNA) to distinguish among soil sources of airborne dust and to test these markers in source apportionment for fugitive dust. If we can distinguish the specific source of dust contributing to elevated particle levels, we can more effectively target controls to reduce emissions.

- **Remote Sensing of Ammonia:** Measuring ammonia emissions – both from sources and in ambient air – is technologically challenging. Using an advanced remote sensing device, ammonia emissions from complex sources, such as cattle feedlots or fertilized fields, can be more completely characterized. In addition, ammonia can be present in significant concentrations several hundred meters above the surface. With this ground-based remote sensing lidar technology, ammonia concentrations aloft can be measured. This technique will be used during the California Regional PM10/PM2.5 Air Quality Study.

- **Comparison of Particulate Matter Concentrations on Weekdays and Weekends:** We are analyzing particle concentrations by day of the week to see if there are any consistent variations in concentrations between weekdays and weekends. Because of the contribution of NOx and VOC precursors to secondary particle formation, we are also analyzing whether the variations by day of week in these precursors are evident in ambient particle levels.

Emission Inventory Development Projects

- **Ammonia Emissions From Fertilizer Application and Soils:** Working closely with the agricultural community, this project will apply various ammonia-based fertilizers to different soil and crop types in the San Joaquin Valley. The ammonia emissions that result from the fertilizer application will be quantified, and the data used to generate regional and seasonal estimates of fertilizer related ammonia emissions.

- **Commercial Charbroiling and Deep-Fat Frying Operations:** The results of this project will allow us to estimate regional and statewide particulate emissions resulting from commercial charbroiling and deep-fat frying based on the number and location of these sources, and estimates of the quantities of food cooked.

- **Dust Emissions From Vehicle Travel Over Paved Roads:** This project will use a vehicle instrumented with real-time particulate measuring devices to develop more accurate estimates of dust from vehicular travel on paved roads. This information will help provide an understanding of what activities lead to high road dust emission rates and what can be done to reduce them.

- **Emissions From Wildland Fires:** This project will provide a consistent, statewide method for estimating smoke emissions from wildland fires, incorporating satellite data, geographic vegetation data, fire modeling, and other available information. The work is being closely coordinated with staff from the California Department of Forestry and the U.S. Forest Service to take full advantage of the wildland burning expertise these agencies possess.

- **Vehicle Travel on Unpaved Roads:** This project will provide better estimates of vehicle activity on unpaved roads within California. This information will help to correct deficiencies in how unpaved road dust estimates are currently calculated and will aid in producing more effective dust control strategies.

- **Evaluation of Geologic Dust Near Emission Sources:** Based on analysis of ambient air, it appears that existing estimates of particulate matter emissions from dust sources may be too large. This project will explore how the dust from sources such as unpaved roads and agricultural fields travels in the air and how long it stays suspended. This work will help us better understand the contribution of dust sources to regional particulate levels.

- **Emissions from Wood-Burning Stoves and Fireplaces:** This project will develop better estimates of particle and precursor emissions from woodstoves and fireplaces by improving our understanding of when and where these emissions occur.

- **Emissions from Agricultural Burning:** This project will evaluate and improve the methods used in California to estimate particulate and other emissions from

burning prunings and other agricultural residues. This work will be coordinated with industry representatives and burn managers to help us better quantify the impacts of agricultural burning.

- **Ammonia Measurement Instrumentation:** This project will develop instrumentation which will allow characterization of ammonia plumes in near real-time. The results of the project will ultimately help to evaluate ammonia emission levels from sources that are difficult to measure using standard techniques and determine how to best reduce ammonia levels if needed.

- **Testing for Exhaust Emissions of Diesel Powered Off-Road Engines:** This project will develop test cycles for off-road equipment based on real world activity and use. In this project, a variety of diesel powered equipment will be instrumented to record their activity in the field. Based on the measured in-use activity parameters such as engine speed and torque collected during this task, an appropriate emissions testing cycle will be determined. Engines from the in-use equipment will be removed and tested for ROG, NOx, and particulate matter.

- **Duty-Cycle Development and Emission Testing of Personal Watercraft:** The objectives of the project are to: (1) instrument personal watercraft that are representative of the in-use fleet in California and collect in-use activity data; (2) derive a real-world emissions test cycle; and (3) perform emissions tests (including particulate matter) using the cycle developed during this study.

- **Particulate Emissions from Marine Outboard Engines, Personal Watercraft, and Small Off-Road Equipment:** The purpose of this contract is to: (1) develop a sampling methodology for measuring PM emissions from outboard marine and personal watercraft engines; (2) measure PM (including PM2.5) and polycyclic aromatic hydrocarbon (PAH) levels from outboard marine, personal watercraft, and two-stroke, small off-road engines; and (3) determine particle size distribution and mutagenic toxicity of PM from these engines.

- **Emissions Testing of Low-Emitting Two-Stroke Utility Engines for Criteria Pollutants, PM10 and PM2.5:** During this project, low-emitting, two-stroke engines will be tested in a brand new condition and after several hours of usage in order to evaluate how emissions change with usage. Testing will include the measurement of particulate matter and other criteria pollutants.

- **Characterization of Particulate Matter Emissions from Motor Vehicles:** In November 1999, we began an 18-month study to measure ambient emissions of ultrafine particles (less than 0.1 microns) and nanoparticles (less than 0.05 microns) from motor vehicles. Measurements will be made on and near roadways where concentrations are expected to be highest. Both the physical and chemical attributes of particulate matter emissions from gasoline and diesel vehicles will be characterized, with an emphasis on ultrafine and nanoparticles.

- **Heavy-Duty Vehicle Chassis Dynamometer Testing at Los Angeles Metropolitan Transit Authority (MTA) Facility:** ARB has taken over the heavy-duty vehicle chassis dynamometer testing facility originally managed by the MTA. This facility will be used to perform both engine- and chassis-based emissions tests (including PM2.5) of heavy-duty vehicles on a regular basis. Data will be used to update the emissions inventory.

- Ammonia Emissions from Motor Vehicles: We are investigating ammonia in motor vehicle exhaust as a significant contributor to secondary pollutant formations.

Air Quality Modeling Research Projects

- **Particulate Matter Modeling Improvements:** We are currently evaluating potential particulate matter models using data collected during a 1995 field study in central California. We have applied ARB's urban airshed model to simulate a January 1995 episode and found limitations in the model's ability to accurately simulate the formation of secondary organic particles. We have already started a research contract to address this issue. We are also planning a collaborative project with the University of California at Davis to improve the way we model chemical reactions in the atmosphere and to make other improvements to the model. In the near future, we will evaluate the same episode with an updated version of the model.

- **Atmospheric Model Development:** This research project is to develop the next generation of models to better simulate the atmospheric reactions among precursors that form secondary particles. The model will include, for the first time, treatment of inorganic and organic constituents simultaneously. This research is crucial to our ability to model both the inorganic and organic fractions of PM2.5 and, therefore, to construct comprehensive photochemical models for attainment plans.

Control Strategy Development and Implementation

- **Evaluation of Technologies to Meet Future Diesel Off-Road Engine Emission Standards:** The purpose of this project is to evaluate potential technologies that could be used to meet future lower NOx and PM emissions standards for diesel off-road engines.